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OMEGA Experiments Show Favorable 2ω Laser–Plasma Interactions at Intensities Relevant for Driving Ignition Hohlraums

The feasibility of driving NIF ignition hohlraums with more plentiful green (2ω) laser energy rather than blue (3ω) laser energy is being investigated at the OMEGA laser in large-scale-length gasbag plasmas. For this purpose, a 1-ns-long, 0.5-ns-delayed 300- to 400-J OMEGA beam has been converted to 2ω, smoothed by a phase plate and focused to a 200-µm spot into CH gas plasmas with NIF-ignition hohlraum relevant densities of $6 \times 10^{20} \mathrm{cm}^{-3}$ (~15% critical density) and temperatures of 2 keV < T_e < 3 keV. The coupling of the 2ω laser light with the plasma and any resultant plasma perturbations is inferred from full-aperture spectrally resolved backscattering measurements of the stimulated Raman scattering (SRS) and stimulated Brillouin scattering (SBS). Figure 1 shows the SRS spectra for intensities increasing from 3×10^{14} W cm^{-2} to 10^{15} W cm^{-2}. First, we observe small SRS losses of 4% for the lowest beam intensity, increasing to 15% at the highest intensity. Second, the spectral width of the main scattered peak, which is a direct measure of the range of plasma densities sampled, broadens significantly only at the higher intensities. This is attributed to reaching an intensity threshold such that beam hot spots can eject plasma transversely, leading to small-scale plasma density nonuniformities. These nonuniformities lead to laser beam self-focusing ("filamentation") and refraction ("beam spraying") that can make it difficult to control hohlraum drive symmetry. They can also lead to an underestimate of the backscattering levels due to light spray outside of the detector. The measurements and their interpretation are consistent with pF3D simulations indicating that the 2ω beam propagates with little filamentation through the OMEGA plasma for 3×10^{14} W cm^{-2}, but undergoes strong filamentation and refraction at 10^{15} W cm^{-2} (see Figure 2). The low backscatter and apparent lack of filamentation at 3×10^{14} is particularly interesting because that intensity is greater than / equal to the intensities used in current 2ω ignition hohlraum designs. Early experiments on NIF have been proposed to continue studying the propagation and backscattering of green laser beams in higher temperature plasmas and at larger scale lengths.

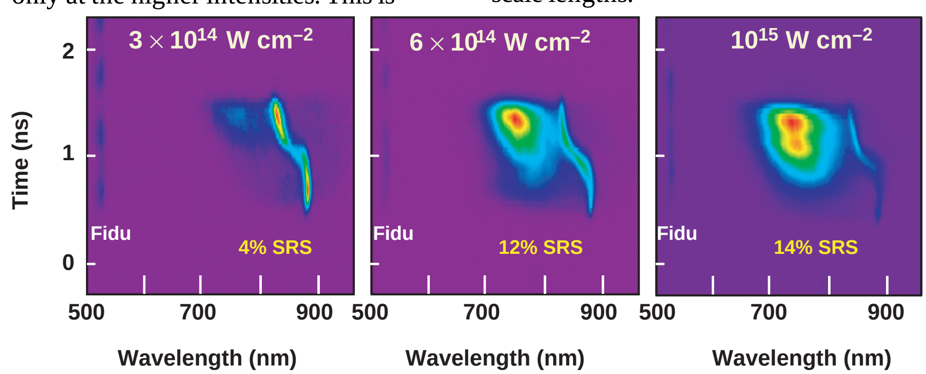


Figure 1. Temporally resolved SRS spectra for various green laser beam intensities.

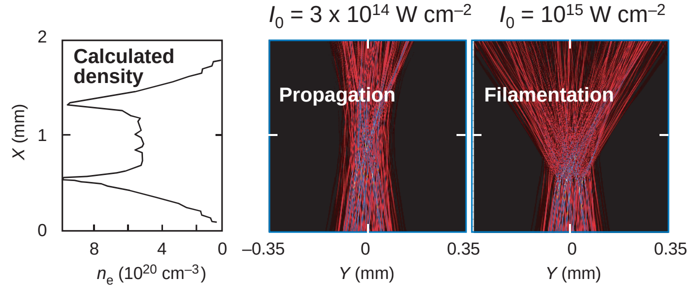
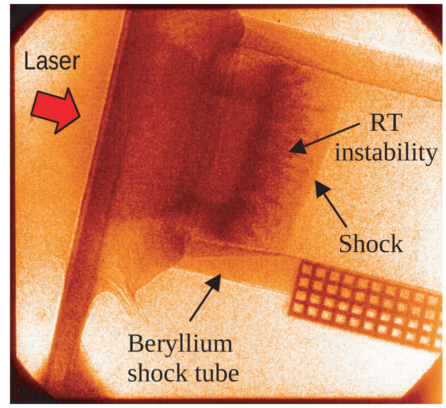


Figure 2. pF3D simulations for two laser beam intensities and calculated electron density profile.



Point Projection X-Ray Radiography of Hydrodynamic Instability at OMEGA

An improved x-ray radiography technique has recently been extended to high-resolution, high-magnification imaging of detailed hydrodynamic phenomena on the OMEGA laser. It employs a small number of laser beams incident on a thin metal backlighter foil to generate a moderate-sized x-ray source, which is apertured by a pinhole to provide arbitrary-duration point projection radiography. The technique, previously deployed for 40-µm-resolution radiography of NIF-scale ICF capsules, was used with 10-µm pinholes to produce very smooth, large field of view, high-magnification (20×) backlit illumination of the evolving target structure, whose image is then recorded and gated with an x-ray framing camera. It offers a more uniform background illumination, a much larger field of view, improved signal-to-noise statistics, and a significant reduction in the required backlighter energy to radiograph a large area—all of which will be essential for the larger targets on NIF. In the image above, the technique is used to measure Richtmyer–Meshkov and Rayleigh–Taylor instability growth that is initiated by passage of a shock through a perturbed interface between two materials. The unstable interface is seen as well as the shock front propagating into the lower density material. With the large field of view, even the shock propagating outward into the Beryllium shock tube wall can be seen.

For comments about content of the ***Bimonthly Update,*** contact Bruce A. Hammel (925) 422-3299.
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